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PATENT APPLICATION

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In re the Application of

Kiminori SATO et al. Attn: PCT Branch

Application No. New U.S. National Phase of PCT/JP2004/018823

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For: METAL-BASED CARBON FIBER COMPOSITE MATERIAL AND METHOD FOR PRODUCING THE SAME

TRANSMITTAL OF TRANSLATION OF THE ANNEXES TO THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

Commissioner for Patents
P.O. Box 1450
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Sir:

Attached hereto is a translation of the annexes to the International Preliminary Report on Patentability (Form PCT/IPEA/409). The attached translated material replaces the material in the specification at page 4, line 1 (starting with the words "carbon fiber is coated") to page 6, line 27, and page 27, line 1 (starting with the words "containing 2 % by weight") to line 27, and the claims in their entirety starting from page 29 through page 32.

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carbon fiber is coated and the method in which carbon-based binders are used to form a preform, and consequently result in an increased cost of composite materials. Further, the method in which the alloy is used as a liquidized metal requires a step of preparing the alloy. Further, all of the methods require a great amount of energy, since the metal or the alloy used as the matrix must be treated at high temperature for liquidizing them.

[0008]

In contrast, the present invention is to provide a method for producing a metal-based carbon fiber composite material by using commonly available and inexpensive raw materials at less energy consumption, with inhibiting formation of carbides, and the metal-based carbon fiber composite material produced by the method.

Means for Solving the Problems

[0009]

A metal-based carbon fiber composite material of a first embodiment of the present invention is a metal-based carbon fiber composite material obtained by sintering of metal and carbon fiber, in which the carbon fiber is contained in a range from 10 to 80 % by weight based on a total weight of the composite material, and the composite material is sintered at 70% or more of ideal density and the carbon fiber is continuously aligned from one end of the composite material to the other end. The carbon fiber may be selected from the group consisting of a pitch-based carbon fiber, a PAN-based carbon fiber,

a vapor-phase grown carbon fiber, a carbon nanotube, and a nanotube/nanofiber twisted (stranded) wire. The metal may be selected from the group consisting of copper, aluminum, magnesium and alloys thereof. Further, the metal-based carbon fiber composite material preferably has a density of 2.6g/cm^3 or lower where aluminum or its alloy is used as metal, 6.8g/cm^3 or lower where copper or its alloy is used as metal, and 2.1g/cm^3 or lower where magnesium or its alloy is used as metal. ~~Further,~~It is preferable that the carbon fiber is contained in a range from 45 to 80 % by weight based on the total ~~may be aligned in the metal-based carbon fiber~~weight of the composite material. In this ~~instance, it is preferable~~case, it is desirable to have a thermal conductivity of 300W/mK or more in the aligning direction of carbon fiber. The above-described metal-based carbon fiber composite material may be used in a heat-dissipating member (base plate, heat sink, heat spreader or the like) for semiconductor-used electronic equipment and a power module.

[0010]

A method for producing a metal-based carbon fiber composite material of a second embodiment of the present invention is characterized by step 1 of obtaining a metal fiber mixture by physically mixing carbon fiber with metal powder, step 2 of filling the metal fiber mixture into a jig, while the metal fiber mixture is aligned, and step 3 of setting the jig in an air, in a vacuum or in an inert gas atmosphere and directly supplying pulse electric current to the metal fiber mixture, with applying the

pressure, to effect sintering by the heat generated therefrom. The carbon fiber may be selected from the group consisting of a pitch-based carbon fiber, a PAN-based carbon fiber, a vapor-phase grown carbon fiber, a carbon nanotube, and nanotube/nanofiber twisted wire. The metal may be selected from the group consisting of copper, aluminum, magnesium and alloys thereof. ~~Where~~Alternatively, the carbon fiber ~~has a fiber length of from 100nm to 5mm, the step 1 can be conducted by a physical mixing method in which a ball mill or the like is used. Where the carbon fiber has a fiber length of 5mm or more, the step 1 can be conducted by a physical mixing method in which a rod mill having rods of an appropriate diameter is used to maintain the direction of fiber. The carbon fiber~~ may be~~preferably~~ a mixture of pitch-based carbon fiber, PAN-based carbon fiber or nanotube/nanofiber twisted wire with vapor-phase grown carbon fiber or carbon nanotube. Further, in the step 2, the direction of carbon fiber may be~~also~~ controlled in a two-dimensional manner. Herein, the fiber length of the carbon fibers, which are not continuous from one end of the material to the other end, is from 100nm to 5mm, the step 1 may be conducted by a physical mixing method in which a ball mill or the like is used. Alternatively, the fiber length of carbon fibers, which are continuous from one end of the composite material to the other end, is the same as the dimension of the composite material, and the step 1 may be conducted by a physical mixing method in which the direction of the fibers is maintained.

Advantages of the Invention
[0011]

By employing the above-described constitution, it become possible to obtain a metal-based carbon fiber composite material which is light in weight and high in thermal conductivity. The obtained composite material is useful as a heat-dissipating member (base plate, heat sink,

containing 2 % by weight (based on the weight of ethanol) of a dispersant-adhesive (Pluronic (registered trade mark) F68) to form a metal powder suspension. The content of copper powder was 60 % by weight based on the weight of the suspension. The bundle of carbon fiber was unwound from the unwinding bobbin, immersed into the metal powder suspension under agitation, taken up in the air, subjected to hot-air drying (50°C) and wound up around a winding bobbin to obtain a bundle of carbon fiber to which copper powder is attached.

[0046]

The obtained ~~aluminum-powder-attached~~copper-powder-attached bundle of carbon fiber was unwound and cut into a strip 20mm in length. While the fiber bundle was aligned in one direction, 12 gram of the bundle was laid into the rectangular recess (20mm × 20mm) formed by the lower punch and the die. Then, a pressure inside the equipment was set 10Pa and the upper punch was disposed on the laid fiber bundle, to which the pressure of 25MPa was applied by a plunger. Then, pulse electric current having pulse duration of 0.01 seconds; current density of $5\times10^6 A/m^2$ (maximum); and voltage of 8V (maximum) flowed for 10 minutes through the fiber bundle by using the power source connected to the upper and lower punches, thereby sintering the copper-powder-attached fiber bundle to obtain a metal-based carbon fiber composite material.

[0047]

CLAIMS

1. A metal-based carbon fiber composite material obtained by sintering of metal and carbon fiber, the composite material comprising 10 to 80% by weight of the carbon fiber based on a total weight of the composite material and the composite material being sintered at 70% or more of ideal density and the carbon fiber is continuously aligned from one end to the other end of the composite material.

2. The metal-based carbon fiber composite material as claimed in Claim 1, wherein the carbon fiber is selected from the group consisting of pitch-based carbon fiber, PAN-based carbon fiber, vapor-phase grown carbon fiber, carbon nanotube and nanotube/nanofiber twisted wire.

3. The metal-based carbon fiber composite material as claimed in Claim 1, wherein the metal is selected from the group consisting of copper, aluminum, magnesium and their alloys.

4. The metal-based carbon fiber composite material as claimed in Claim 3, wherein the metal is aluminum or its alloy, and the composite material has a density of $2.6 g/cm^3$ or less.

5. The metal-based carbon fiber composite material as claimed in Claim 3, wherein the metal is copper or its alloy and the composite material has a density of $6.8 g/cm^3$ or less.

6. The metal-based carbon fiber composite material as claimed in Claim 3, wherein the metal is magnesium or its alloy and the composite material has a density of 2.1g/cm^3 or less.

7. The metal-based carbon fiber composite material as claimed in Claim 1, wherein the carbon fiber is aligned.

8. The metal-based carbon fiber composite material, as claimed in ~~Claim 7~~<u>Claim 21</u>, wherein a thermal conductivity is 300W/mK or more in the arrangement direction of the carbon fiber.

9. Electronic equipment with semiconductors, wherein the metal-based carbon fiber composite material as claimed in any one of ~~Claims 1 to 8~~<u>Claims 1 to 6, Claim 8 or Claim 21</u> is used as a heat-dissipating member.

10. A power module, wherein the metal-based carbon fiber composite material as claimed in any one of ~~Claims 1 to 8~~ <u>Claims 1 to 6, Claim 8 or Claim 21</u> is used as a heat-dissipating member.

11. A method for producing a metal-based carbon fiber composite material, comprising the steps of:
step 1: obtaining a metal fiber mixture by physically mixing carbon fiber with metal powder;
step 2: filling the metal fiber mixture into a jig, while the metal fiber mixture is aligned, and
step 3: setting the jig in the air, in a vacuum or in an inert gas atmosphere and directly supplying pulse electric current to the metal fiber mixture, with

applying the pressure, to effect sintering by the heat generated therefrom.

12. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein the carbon fiber is selected from the group consisting of pitch-based carbon fiber, PAN-based carbon fiber, vapor-phase grown carbon fiber, carbon nanotube, and nanotube/nanofiber twisted wire.

13. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein the metal is selected from the group consisting of copper, aluminum, magnesium and their alloys.

14. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein the carbon fiber has a fiber length of from 100nm to 5mm and the step 1is conducted by a physical mixing method in which a ball mill or the like is used.

15. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein the carbon fiber has a fiber length of 5mm or more and the step 1 is conducted by a physical mixing method in which the direction of fiber is maintained.

16. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein the carbon fiber has a fiber length of 100mm or more and the step 1 is conducted by immersing a fiber bundle into a metal powder suspension.

17. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein the carbon fiber is a mixture of pitch-based carbon fiber, PAN-based carbon fiber or nanotube/nanofiber twisted wire with vapor-phase grown carbon fiber or carbon nanotube.

18. The method for producing a metal-based carbon fiber composite material as claimed in Claim 11, wherein in the step 2, the direction of carbon fiber is controlled in a two-dimensional manner.

19. The method for producing a metal-based carbon fiber composite material as set forth in Claim 11, wherein, among the carbon fibers, those which are not continuous from one end of the composite material to the other end have the fiber length of 100nm to 5mm, and the step 1 is conducted by a physical mixing method in which a ball mill or the like is used.

20. The method for producing a metal-based carbon fiber composite material as set forth in Claim 11, wherein, among the carbon fibers, those which are continuous from one end of the composite material to the other end have the fiber length of the same as the dimension of the composite material, and the step 1 is conducted by a physical mixing method in which the direction of fiber is maintained.

21. The metal-based carbon fiber composite material as set forth in Claim 1, comprising 45 to 80 % by weight of the carbon fiber, based on the total weight of the composite material.